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RESEARCH ARTICLE

ECOLOGY OF VASCULAR EPIPHYTIC PLANTS IN GEDEO AGRO- FORESTRY SYSTEM, SOUTHERN ETHIOPIA

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ABSTRACT

The Ecology of vascular epiphytes was studied in agro forestry system of Gedeo Zone, Southern Nation, Nationalities and Peoples National Regional State of Ethiopia at an altitude of 1370 -3100m. Systematic sampling method was employed during data collection. Different software's like CANOCO, TWINSPAN, PAST and SPSS were used to analyze the data and also qualitative analysis was followed depending up the raw data collected. Eleven species of vascular epiphytes were recorded from nine host (phorophyte) species in the study area. The analysis by TWINSPAN and ordination showed as there are two plant community associations without vegetation disparity among the zone and ferns were the species rich group. The species diversity of vascular epiphyte is greatly influenced by the host tree biophysical factors, such as vertical gradient of host, bark texture, size, age, and surface area. The changing forest structure across altitude provides different quantities and qualities of substrate to epiphytes that resulted in decreasing number of epiphyte species with increasing elevation. The altitudinal distribution of epiphytes may be influenced by altitudinal factors like temperature and moisture. The vertical distribution of vascular epiphytes along the vertical gradient of the host trees indicated that most species were localized at the intermediate height. The vertical ecological gradients (i.e. solar radiation and humidity differences from the forest floor to the canopy) may be relevant for the distribution of epiphyte floras. The host tree specificity of vascular epiphytes was not exhibited by the current study. The species richness of epiphytic plants varies depending up on the season. Therefore one who wants to conduct further research on the aspect of epiphytic plants should be care of the season at which the study is conducted.

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INTRODUCTION

There are different definitions of epiphyte by different authors at different times. Originally, the name epiphyte is derived from two Greek words ‟epi = upon; phyton = plants" (Jacques and Morris, 1995). Also Heywood (1993), Fatland (1996), Hietz (1999) and Benzing (2004) defined an epiphyte as a plant that root and perch on the surface of another plant or non-living objects without driving food from its host. Furthermore, Schubert (1990) defined phorophyte as a host plant used by an epiphyte for physical support. Vascular epiphytes include over 25,000 species of plants, in about 44 orders, 84 families and 879 genera, accounting for about 10% of all plant species (Kress, 1986 and Kromer *et al.*, 2007). The majority of them are ferns and monocots especially Orchidaceae, Bromiliaceae and Araceae and relatively few are dicots (e.g.Ericaceae, Gesneriaceae, Piperomiaceae), but virtually none are gymnosperms (Barthlott *et al.*, 2001). They obtain water, minerals, and nutrients from the environment than host trees by specialized tissues and roots that evolved the abilities to derive better support and assimilate water and nutrients from surfaces other than the ground (Benzing, 1987), (Hietz, 1999), (Elias Nune, 2008) and (Woolley and Lacher, 2008). According to Turner *et al.*, (1994) vascular epiphytes are vulnerable group and consequently represent a good indicator group of biodiversity that can be monitored to assess the effects of forest disturbance. Epiphytes interact with the environment in different ways like Symbiotic associations with organisms, Providing economic, medicinal and horticultural products for human use, Contributing to nutrient cycles and biodiversity, Acting as global environmental change indicators and create an arena for observational and experimental studies (Nadkarni,1992) and (Kromer *et al.*, 2007). Secondary vegetation is not poor in epiphyte diversity in all cases as shade trees of coffee may host a diverse epiphyte community and Gedeo agroforestry system is well known by its large shade trees of coffee which harbored many epiphytic plant communities. The present study was aimed to address the ecology of vascular epiphytic plants in Gedeo Agro- forest, Southern Nation, Nationalities and Peoples National Regional States (SNNPNRS), Ethiopia.

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MATERIALS AND METHODS

Description of the Study Area

The Gedeo Agro-forest is a moist Afromontane Forest, located in the Southern Nation, Nationalities and Peoples Regional

National State (SNNPNRS) of Ethiopia between 7°39′N to 7°81′ N latitude and 35° 24′ E and 37° 90′ E longitude. Oromia National Regional State borders the zone on the East, South and West whereas; Sidama zone shares the northern boundary. It lies at an altitude ranging from 1370 to 3100m.a.s.1 and the agro- climatic zone of the region contain Weynadega (67.53%), Dega (32.41%) and Kolla shares 0.6%. The zone is characterized by varied topography, slope and land of outstanding natural beauty with high mountains, steep valleys and rolling plains.

Research Design

A reconnaissance survey of the study area was made from January 1 to 18/2011 and Field data collection was carried out from 20 January, 2011 to 30 February 2011 by systematic sampling method based on the availability of epiphytes and accessibility the area. In the study area, thirty-two, 20x20m quadrants were laid out systematically based on vegetation type in the study site. All vascular epiphytes were recorded on all host trees with diameter at breast height (DBH) ≥10cm found in all plots. Each host tree was divided in to five vertical zones following (Kromer and Gradstein, 2007).

Method of Data Collection

Four sample sites were randomly selected representing the six Woreda's of the zone and specimens of both vascular epiphytes and phorophytes with their qualitative and quantitative data was recorded. The number of vascular epiphytes on each phorophyte was counted, recorded and those epiphytes occurring in dense stands were counted as one individual following (Johansson, 1974; Barthlott *et al.,* 2001). Consistent survey of epiphyte on each tree was carried out following (Burns, 2007).

Data Analysis

The relationship between the size of host trees and the numbers of epiphyte species it hosts, were analyzed by PAST-PAleontological Statistics, version. 1.56 (Ryan *et al*., 1995). For classification and association of plant species, TWINSPAN, a Two-way Indicator Species Analysis, Version 1.0 was used (Hill, 1994 and vander Maarel, 2005). Vegetation ordination analysis was carried out using Detrended Correspondence Analysis (DCA) with CANOCO version 4.5 (ter Braak and Similauer, 2002). Vascular epiphyte diversity was analyzed using Shannon - Weiner diversity index following Magurran (1988) which is calculated by the formula: Host specificity of the epiphytes was analyzed using qualitative data (bark textures of the phorophyte.

RESULTS AND DISCUSSION

Species Diversity of Vascular Epiphytes

In the present study, five families of vascular epiphytes containing eleven species were recorded (Figure 1). In a similar manner, six families' of host plants containing nine species were recorded in the current study. All of the identified species are holoepiphytes (True Epiphytes) and the dominant family is Polypodiaceae (ferns) followed by Orchidaceae and Piperaceae whereas Amaranthaceae and Hemionitidaceae are the least abundant. The Orchidaceae is the most species rich family compared to the other families followed by Polypodiaceae and Piperaceae while a single species is recorded from both Amaranthaceae and Hemionitidaceae families.

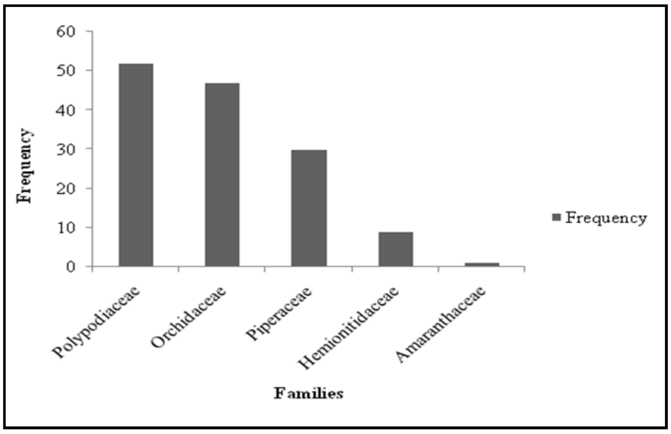

Figure 1. Vascular epiphytic richness by families of Gedeo Zone

In contrast to this finding, Tesfa Alemayehu (2006) recorded 55 species of vascular epiphytes belonging to 35 families and the most species rich family is *Aspleniaceae* followed by *Orchidiaceae* and *Polypodiaceae*. The least species rich family was found to be *Campanulaceae*, *Piperaceae,* and *Urticaceae*. The difference in species diversity of vascular epiphytes recorded by Tesfa and the current study is greatly due to variation in moisture content and nature of the forest (agro forest versus natural closed forest).

Classification

Naming of the plant communities was based on fidelity and the ordered two-way TWINSPAN (Table 1) shows the species on the top are more abundant on the left side of the primary division than on the right side. The species on the bottom are more abundant on the right side of the primary division than on the left side. The species in the middle are somewhat constant, occurring widely on both sides. TWINSPAN used one species, *Persia americana* as an indicator species to demarcate the group of samples to the left of the primary division ("Association I"). On the other hand, *Polyscias fulva* was used as an indicator species for the right side of the primary division (Association II). Most of the species in association I are trees, except some epiphytic species namely *Eulophia streptopetala, Diaphananthe candida, Diaphananthe adoxa* and *Peperomia fernandopoiana*. When the association between epiphytes and their host trees were seen, *Eulophia streptopetala* and *Ficus vasta* were associated together.

Two epiphytic species, *Diaphananthe adoxa* and *Diaphananthe candida*, both were associated to *Ficus sycomorus* while *Peperomia fernandopoina* was associated with *Erythrina brucei*. In a similar manner, association among epiphyte themselves was also analyzed and the result indicated that *Diaphananthe candida* and *Diaphananthe adoxa* were associated together in association I.

From TWINSPAN result, one can conclude that selective cutting of some host trees will automatically resulted in total loss of their respective epiphytic plants. Accordingly, selective cutting of *Ficus vasta* and *Erythrina brucei* may eventually lead to the loss of *Eulophia streptopetala* and *Peperomia fernandopoina* respectively and same is true for others.

Table 1. The ordered two-way table form TWINSPAN showing the plant association in the study sites

		1 23 1111	3123 11222	222 1212		
		672481520193	40396285612	403571987		
23	Mang indi	----1-------	-----------	-----------	0010	
29	Pers amer	21111111----	-----------	-----------	0010	
21	Ficu vast	1-111----1--	---11-11---	-----------	0011	
17	Eulo stre	-3-------3--	-----------	-----------	0011	
25	Mesa lenc	----11-1----	-----------	-----------	0011	I
20	Ficu syco	-11---111---	--1-1-1----	-----------	0011	
13	Diap cand	33----23-333	-333--2----	-----------	0011	
12	Diap adox	1-3----32---	-------1---	-----------	011	
15	Eryt bruc	-111212121--	-----2-----	------22111	011	
28	Pepe fern	1-11-111-2-2	2-22-------	-----------	011	
24	Mell ferr	2222122-1111	112-2-21-21	---2-------	011	
26	Pele macr	-2333233343-	22333-1-212	-3223333333	011	
27	Pepe tetr	--332-131343	3-------3--	----3132222	011	
9	Cord afri	1-11---2-1--	11-11122-11	--2-111----	1000	CON
4	Albi gumi	11-1--11-1-1	-111-1-22-1	1-1-1111111	1001	SPP
8	Coff arab	333333333333	33333332323	33333333333	1001	
10	Crot macr	-1-1-111-111	--11-1-2111	1111-111111	1001	
11	Cyto eryt	33---222---1	3-3-33-3132	3--2-23-111	1001	
16	Euca glob	-1----------	---------11	-----------	110	
22	Hage abys	------------	-----1-----	---111-----	110	
32	Prun afri	11-----1----	1--1--111-1	1111--111--	110	
31	Poly fulv	------------	-----------	-1111--1111	1110	
33	Vern amyg	------------	----------1	1-1111-1111	1110	II
34	Vern anth	------------	----------1	-11--1-----	1110	
18	Faga ango	------------	-----------	---1-1-1111	1111	
19	Ficu ovat	------------	-----------	-----1-----	1111	
2	Acyr aspe	-----------	-----------	-------2---	1111	
		0000000C	00000000000	1111111111111		
		00000000	11111111111	0000000011111		
		00111111	00000000001	0000011100011		
		0	00110000001	11100111		
			01	111		
			0	1111		

Key: I= Association one
II= Association two
Con Spp= Constant Species

General Distribution of Vegetation in the Study Area by Ordination

Gedeo's agro-forestry is based on multistory multiple cropping of coffee, indigenous or endemic trees, Enset (the staple food for Gedeo people), tropical fruit trees (Avocado, Mango, Papaya) and garden crops. The data set consisting of 27 species in 32 plots were used in the final ordination with CANOCO package and TWINSPAN with result of Axis 1 (Eigen value = 0.256) Axis 2 (Eigen value = 0.337). The axes are scaled in S.D units. The second axis had an Eigen value of 0.337, which represents the long gradient (3.345 S.D units). This gradient separated the two plant communities namely *Persia americana* (community 1) and *Polyscias fulva* (community 2) from the above table1 and figure 2 below. Generally, the vegetation distribution of the zone was not this much varied and almost all woreda of the zone have similar distribution of vegetation.

Micro-Habitat of Vascular Epiphytes on Host Zones

Distribution of species of vascular epiphytes on the phorophytes is not the same from basal parts to the top most branches. The lists of the species of vascular epiphytes recorded from different section of the phorophyte are given in table 2. Only *Peperomia fernandopoiana* is found distributed throughout the parts covering about 80% of phorophyte followed by *Drynaria volkensis* which covers about 60% of its host zones. The former species grows on all parts of its host except for the last zone (zone five) whereas the later species was not observed from two zones i.e. the first and the last zones (zone one and zone five).

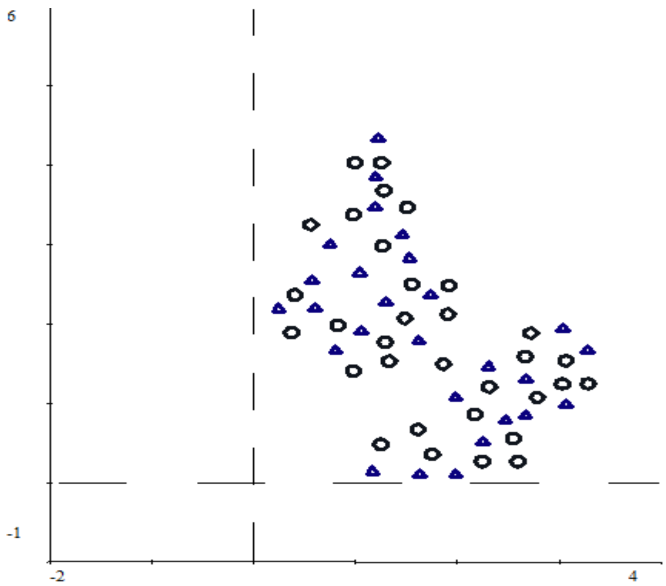

Figure 2. DCA ordination plot obtained by running CANOCO, axis 1 (horizontal) and axis 2 (Vertical). Axes are scaled in S.D. units. Circles represent sample numbers where as triangles represent species

Four species namely *Acyranthes aspera, Cyrtorchis erythraeae, Eulophia streptopetala and Diaphananthe candida* each covers about 40% of their host zones. Generally, most of the epiphytic species abundantly distributed over the middle zones (2 and3) of their host plants. Edwin and Adrianus (2010) also reported the same resulted.

Peperomia fernandopioana (9.09 %) was recorded from a single phorophyte species called *Erythrina brucei*. This means that, there were no phorophyte species holding only a single epiphyte species and all were supporting at least two epiphyte species. Tesfa Alemayehu (2006) also reported that, 90.9 % of vascular holoepiphyte species were not host specific.

Table 2. Micro-Habitat of Vascular Epiphytes on Host Zones

S.No.	Epiphytes	Micro-Habitat on Host Zones				
		Zone1	Zone2	Zone3	Zone4	Zone5
1	*Acyranthes aspera* L.	√	√			
2	*Aerangis brachycarpa (A.Rich.) Th.Dur. & Schin*			√		
3	*Anogromma leptophylla* .Willd	√				
4	*Cyrtorchis erythraeae* (Rolfe) Schltr.	√	√			
5	*Diaphananthe adoxa* Rasm.			√		
6	*Diaphananthe candida* Cribb.			√	√	
7	*Drynaria volkensis* Hieron.		√	√	√	
8	*Eulophia streptopetala* Lindl.			√	√	
9	*Peperomia fernandopoiana* C.DC	√	√	√	√	
10	*Peperomia tetraphylla* (G.Forst.) Hook&Arn		√			
11	*Pleopeltis macrocarpa* (Bory ex Willd.) Kaulf.		√			

Table 3. Distribution of epiphytes among the four sampled areas of the Gedeo Zones

Sites	Epiphyte group	Frequency	Percentage (%)	Diversity indices (H`)	Evenness(J)
	Orchids	13	48.1	.48 or 48%	.9566
1	Fern	9	33.3		
	Peperomia	4	14.8		
	Acyranthes	1	3.7		
	Orchids	11	26.2	.45 or 45%	.9375
2	Fern	21	50		
	Peperomia	10	23.8		
	Orchids	12	28.6	.44 or 44%	.8000
	Fern	21	50		
3	Peperomia	9	21.4		
	Acyranthes	1	3.7		
	Orchids	8	44.4	.38 or 38%	.7916
4	Fern	9	50		
	Peperomia	1	5.6		

Table 4. Summary of one way ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4387.446	3	1462.482	1.812138	0.148651	2.680811
Within Groups	96038.7	119	807.0479			
Total	100426.1	122				

Comparisons of epiphytic species diversity among the four sites

The species diversity of the vascular epiphytes in the study area presented in table 3 and it shows that site four has the lowest diversity (H'= .38) while site one has the highest (H'=.48). This means that site one is the most diversified area of the zone and site four is the least. The other sites namely, site two and three have almost similar diversity indices. Vegetation diversity was also analyzed using single factor ANOVA and the following summary result was found. As summary ANOVA in Table 4 indicates, there is no significance difference in vegetation distribution of plants among the four sites at $P < 0.05$ level of significance. This is because of that F calculated 1.812138 is less than the critical value of F 2.680811 (Table 4).

Host Specificity of Vascular Epiphytes

Most vascular epiphytic species in the study area were not host specific. Ten species (90.01%) of the epiphyte were recorded from two or more host tree species but, one species namely

Thus, it was suggested that true host specificity of epiphytes is rare, but host species can affect epiphytes at least to the extent that some trees have suitable substrates and are densely colonized, whereas others are less suitable with only sparse epiphyte growth on them (Hietz, 2005).

Characteristic structures of phorophyte as a function of diversity of vascular epiphytes

Diameter at breast height (DBH)

The analysis of data collected from phorophytes with different sizes and corresponding number of epiphyte species indicates that, DBH and number of epiphyte species are significantly and positively associated($r^2 = 0.64$; $P<0.01$). Similarly, a scatter plot showed that there is a linear relationship between number of epiphyte species and host sizes (Fig 3). Various authors reported the relationship between phorophytes's DBH and number of epiphyte species and yet all forwarded that as the sizes of phorophytes increase, the number of epiphyte species increase in a linear fashion (Cummings *et al.,* 2006, Liu and Xu 2005, Mehltreter *et al.,* 2005).

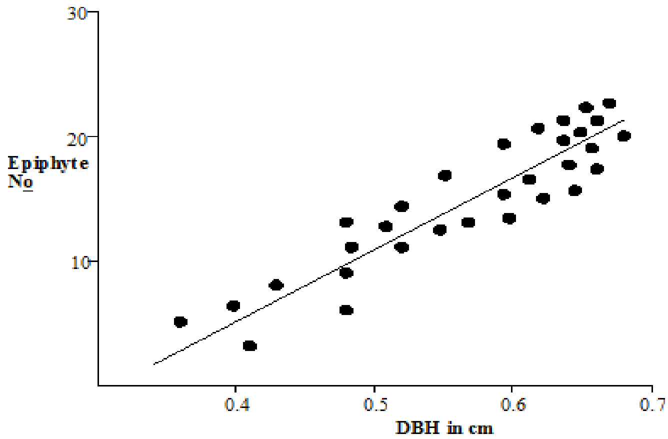

Figure 3. Relationship between DBH host and number of vascular epiphyte species

Bark Texture of Host Plants

Qualitative analysis of bark texture was made based on observation (rough / smooth) and Most of the recorded phorophyte species (88.1%) possessed rough bark texture while 11.9% of them were smooth barked (Table 5). Among species of vascular epiphytes recorded from sampled areas, almost all species (90.9%) were registered from rough barked phorophytes. However, all smooth barks were not necessarily bare as such and therefore support considerable number of species. Different reports revealed that the nature of bark texture of phorophytes in general, determines the number of epiphytes that germinate and grow on the host plants (Benzing, 1987, Munoz, 2003, Nadkarni, 2000 and Mheltreter *et al.,* 2005).

Table 5. List of vascular epiphyte species existing at different bark textures of phorophytes

No	Epiphyte species	Bark texture of the host	
		Rough	Smooth
1	*Aerangis brachycarpa (A.Rich.)Th.Dur. &Schin*	+	+
2	*Acyranthes aspera* L.	+	-
3	*Anogromma leptophylla.*Willd	+	-
4	*Cyrtorchis erythraeae* (Rolfe) Schltr	+	+
5	*Diaphananthe adoxa* Rasm	+	-
6	*Diaphananthe candida* Cribb	+	-
7	*Drynaria volkensis* Hieron.	+	+
8	*Eulophia streptopetala* Lindl	-	+
9	*Peperomia fernandopoiana* C.DC	+	-
10	*Peperomia tetraphylla* (G.Forst.) Hook&Arn	+	+
11	*Pleopeltis macrocarpa* (Bory ex Willd.) Kaulf.	+	+
Total		10	6

Conclusion and Recommendation

The result indicated the influence of anthropogenic disturbance on epiphyte communities and the necessity of forest conservation. Human disturbance appeared to prevent the succession of epiphyte community. However, high forest disturbance like cutting for timber, construction and agriculture were observed in the study area, which caused the change in species diversity and composition of vascular epiphytes. This shows that epiphytes are good indicators of disturbance and climatic change. In general, species diversity of vascular epiphytes in Gedeo Agro- Forest is low; when compared with other tropical forests like that of Harenna Forest of Bale from which 55 species of vascular epiphytes were recorded. There are strong relationships between vascular epiphyte presence /absence and environmental variables and change in habitat structure. Some of the variables are: forest disturbance, vertical gradient of microclimate on single host plant, DBH and bark texture of phorophytes, and elevation. The change in species composition of vascular epiphyte is associated with the changes in these variables. The result of this study demonstrated that epiphyte life is tied to host plants that provide them mechanical support. The host size (DBH) has an effect on number of epiphyte species; the larger the sizes of phorophytes, the more number of epiphyte species on it. Tree bark structure also influence the number of epiphyte species, in that rough textures support more epiphytes than smooth ones. The isolated remnant shade trees in agricultural land with its coffee trees play an important role as forest species repositories. This indicates that vascular epiphyte species found on both shade trees and their coffee trees were all recorded from forest interior. Thus, the tradition of growing coffee under old shade trees is probably an important reason for the relatively good conservation of many epiphytes.

The increasing human interference is becoming a big challenge to Gedeo Agro- Forest in general and vascular epiphytes in particular. Therefore, it is recommended that:

- Since epiphytes species such as *Diaphananthe candida*, *Anogromma leptophylla*, *Drynaria volkensis* and *Peperomia tetraphylla* are vulnerable to any disturbances causing deforestation, they are good indicators of changes in forest structure. Therefore, any reforestation or *in situ* conservation should consider the establishment of vascular epiphytes in newly growing forest.
- The local community is highly dependent on the forest for coffee and timber production. Thus all the local communities of Gedeo zone who's the direct impact of environmental disturbance may face should made awareness and practice sustainable use of natural resource and conservation management.
- The local people have indigenous knowledge of forest conservation. Larger isolated shade trees have been conserved together with their undergrowth coffee trees and other plant species in their garden and farm for decades. Thus, the diversity of coffee management systems, which include traditional polycultures with a range of shade trees, should be encouraged.
- The season at which epiphytes are studied had great effect on the outcome of the work as there were different difficulties faced in finding and recording the epiphytic species. Therefore one who wants to conduct further research on the aspect of epiphytic plants should be care of the season at which the study is conducted.

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